Integrated Micro-Optical Sensors for Condition Monitoring

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Goals/Objectives

Real-time sensing networks based on opto-mechanical micro-sensors will be developed as part of a condition-monitoring network for aircraft structures.

Approach

In this project, we are developing real-time sensing networks based on opto-mechanical micro-sensors. These sensors form part of a condition-monitoring network for aircraft structures. Specifically, the emphasis is on identifying and developing useful applications of micro- and nano-sensors for condition monitoring of aircraft structures or engines, and to select appropriate sensors networks for both in-flight and maintenance-facility condition monitoring. The sensor network can be surface-mounted on existing metallic structures or integrated into future composite structures. A significant part of the project is concerned with the development and testing of sensors for specific applications.

Specifically the following *opto-mechanical micro-sensors* are being developed: (i) acoustic emission sensors for the detection of crack- and impact-damage nucleation and generation; and (ii) micro-beam accelerometers with optical pick up (and no electrical components) for use in fire-hazardous areas for monitoring of excessive vibration. For in-flight condition monitoring, the signals from the sensor networks will be fiber-optically routed to centrally-located demodulation units where they are converted to electrical signals for processing by an on-board computer, with the results either stored locally or possibly telemetrically reported to a land-based facility.

An integral part of the project is the development of compact sensor demodulation units that can handle optical signals from several sensors. Multiplexed two-wave mixing technology recently developed at NU is used for this (Ref [1]). A schematic of this PhotoRefractive Array Demodulator (PRAD) system is shown in Figure 1.

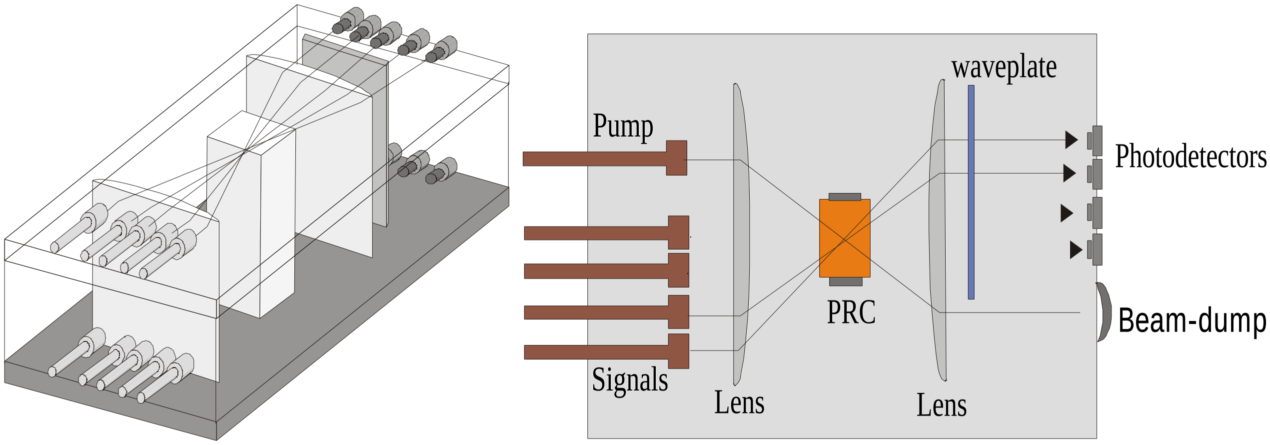

Figure 1: Photorefractive Array Demodulator: (Left) Exploded view of layers (only top and bottom layers are shown for illustration purposes); and (Right) details of each layer. Note that a single PRC, set of cylindrical lenses and a waveplate are shared by all the layers.

Accomplishments

- PhotoRefractive Array Demodulator (PRAD): An 8-channel fiber-optic PRAD has been designed and a prototype is being built. This system uses multiplexed two-wave mixing in photorefractive BSO crystals. The system design enables simultaneous demodulation of micro-optical sensor signals from eight channels (REF [2]).
- Fabrication of micro-optical sensors: We are now authorized users of the Micro-fabrication Applications Laboratory at the University of Illinois, Chicago. We currently have the ability to make optically flat and reflective nanometer-thick thin films. These will form the basis for the proposed micro-optical sensors that will be fabricated over the next several quarters.

Future Work

The PRAD device will be miniaturized using silicon wafer alignment platforms, and a 32 channel device will be designed and tested. Fabrication of thin film cantilever beams (~100 nanometer thick and ~100 microns wide) will begin in the next quarter. These will be used to fabricate micro-optical sensors.

References

1. Todd W. Murray and Sridhar Krishnaswamy, (2001), "Multiplexed Interferometer for Ultrasonic Imaging Applications," Optical Engineering, vol. 40, No. 7, pp1321-1328.
2. P. F. Fomitchov, T.W. Murray and Sridhar Krishnaswamy, " Intrinsic Fiber Optic Sensor Array using Multiplexed Two-wave Mixing Interferometry," Applied Optics , vol 41, No.7, (March 2002).